Review of Key Concepts for Managing Nonpoint Source Pollution

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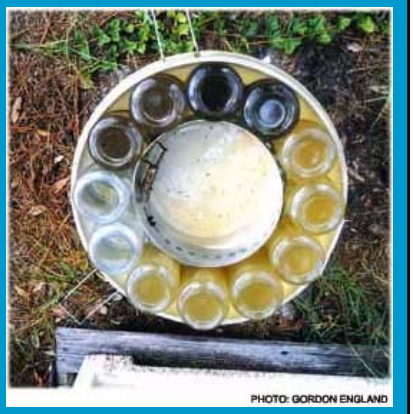
Tetra Tech

Nonpoint Source Pollution: The Basics

- Rainfall, snowmelt, or irrigation runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, or the ocean or introduces them into ground water.
- NPS pollution is responsible for more than half of the nation's remaining water quality problems.
- The cumulative impact from many nonpoint sources degrades water quality.

Getting a handle on nonpoint source pollution

- We can define what we want to use the water for (designated uses)
- We can measure how clean the water has to be to support those uses (water quality criteria)
- We can measure what the water quality is now (ambient water quality conditions)



Physical, chemical, and biological factors are most often measured, but flow and energy (mostly sunlight) can be important considerations

Figure 6: Monitoring Types and Pollutants or Conditions That They Measure

Biological

Assesses:
- Structure and function of aquatic communities
- Habitat, such as condition of riparian vegetation
- Health and abundance of aquatic species or fish populations

Physical

Measures:
- Temperature
- Conductivity
- Transparency
- Total suspended solids

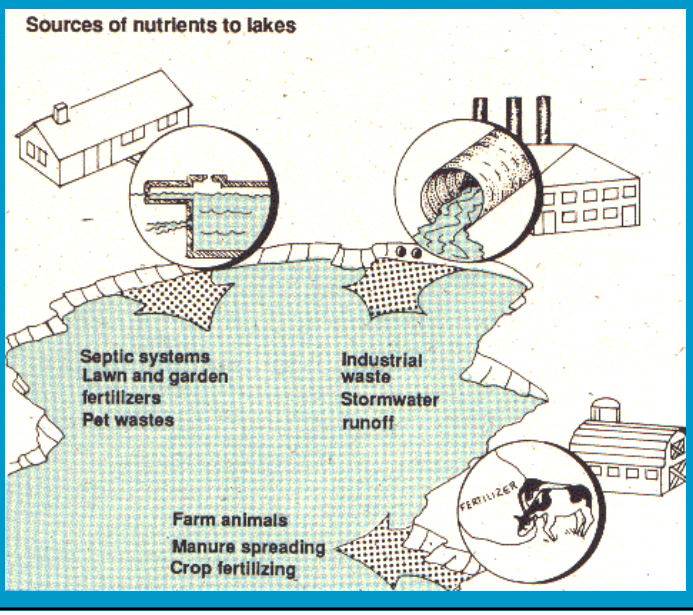
Chemical

Tests for levels of:
- Pesticides
- Organics
- Metals (cadmium, arsenic, etc.)
- Nutrients (phosphorous, nitrogen)
- Toxic materials in fish tissue

Common NPS pollutants: nutrients

NPK

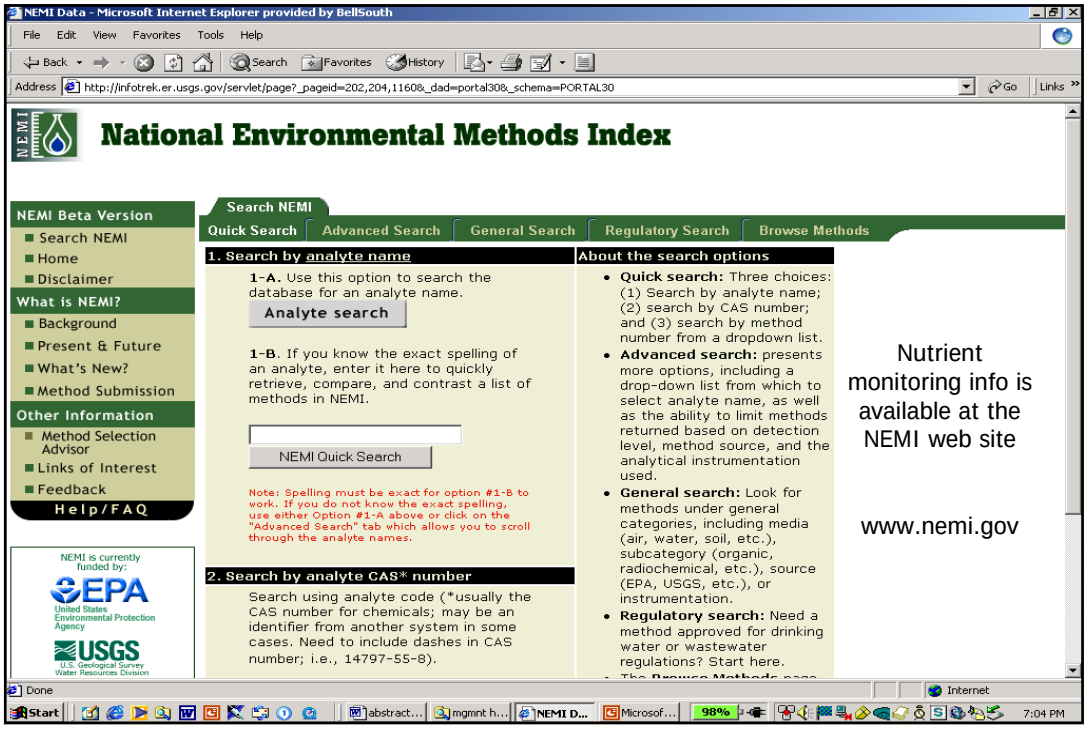
Nitrogen, phosphorus, and potassium



Nutrients

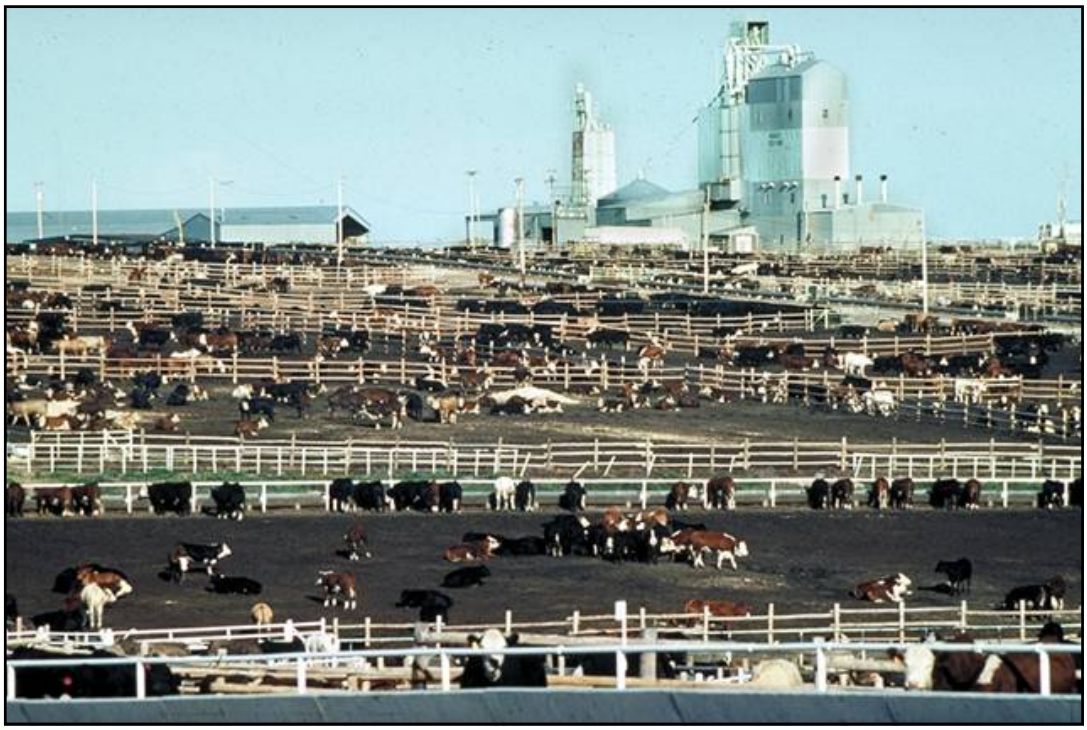
Most inland fresh waters will “bloom” with algae when phosphorus is added.

Bacteria that decompose algae suck dissolved oxygen out of the water, and can lead to fish kills

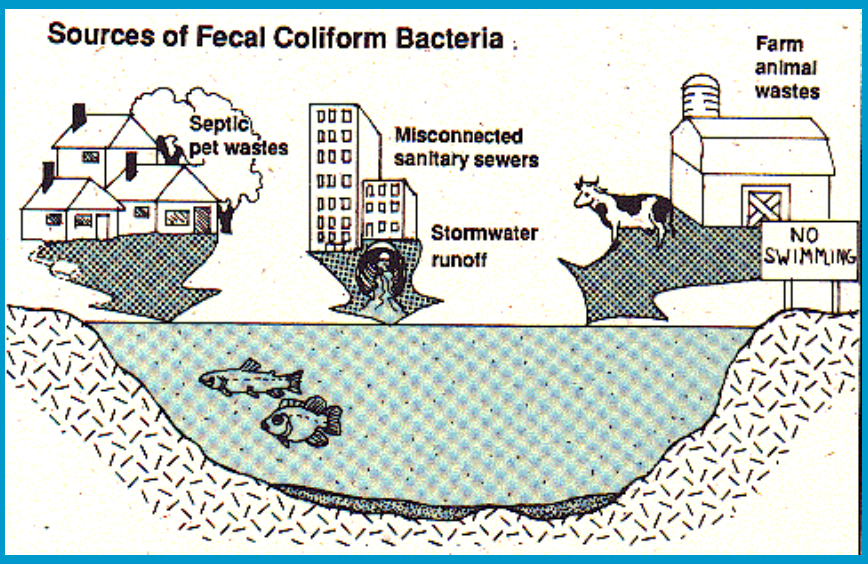


Nutrient monitoring info is available at the NEMI web site

www.nemi.gov



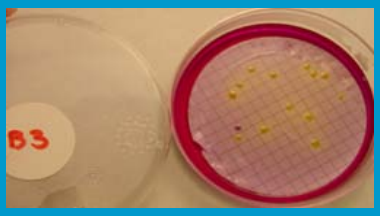
Common NPS pollutants: bacteria

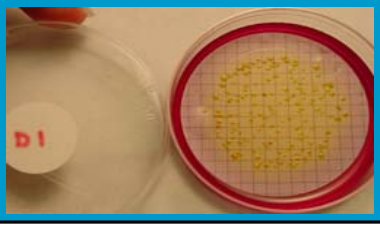


Straight pipe or malfunctioning septic systems

- Pipe from septic tank to ditch
- Fairly common for older, rural homes
- Direct discharges to creeks, field tiles/drains, ditches (should have NPDES permit coverage)
- Lots of new technologies, can use CWA 319 funding to fix them

Most programs measure fecal coliform bacteria “colony-forming units” per 100 milliliters of raw water, or E. coli counts



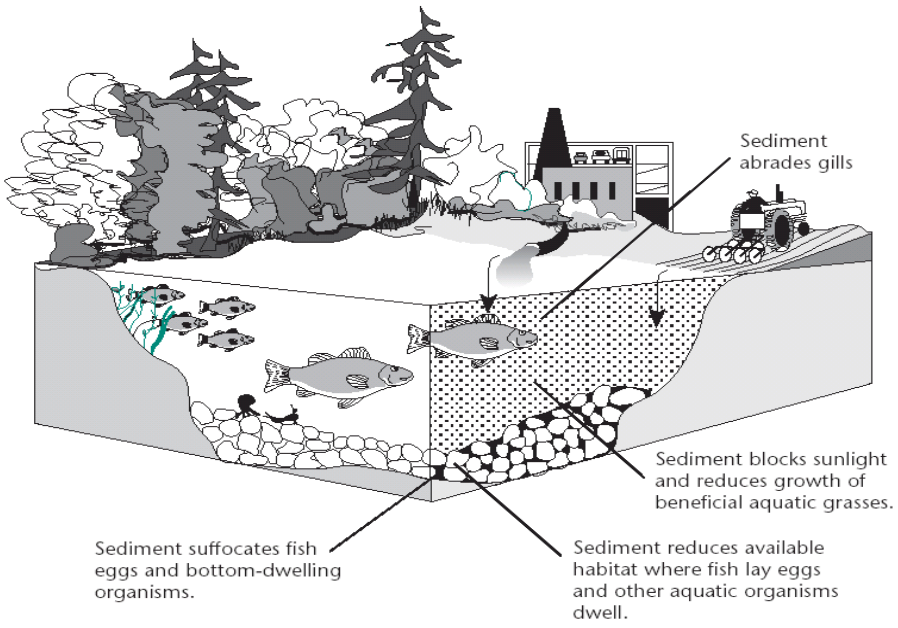


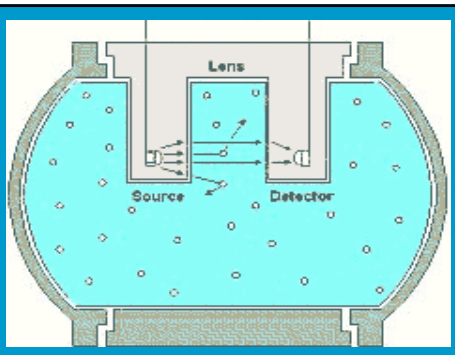
Common NPS pollutants: sediment

Key sources: stream/river banks, farm fields, ***construction sites***

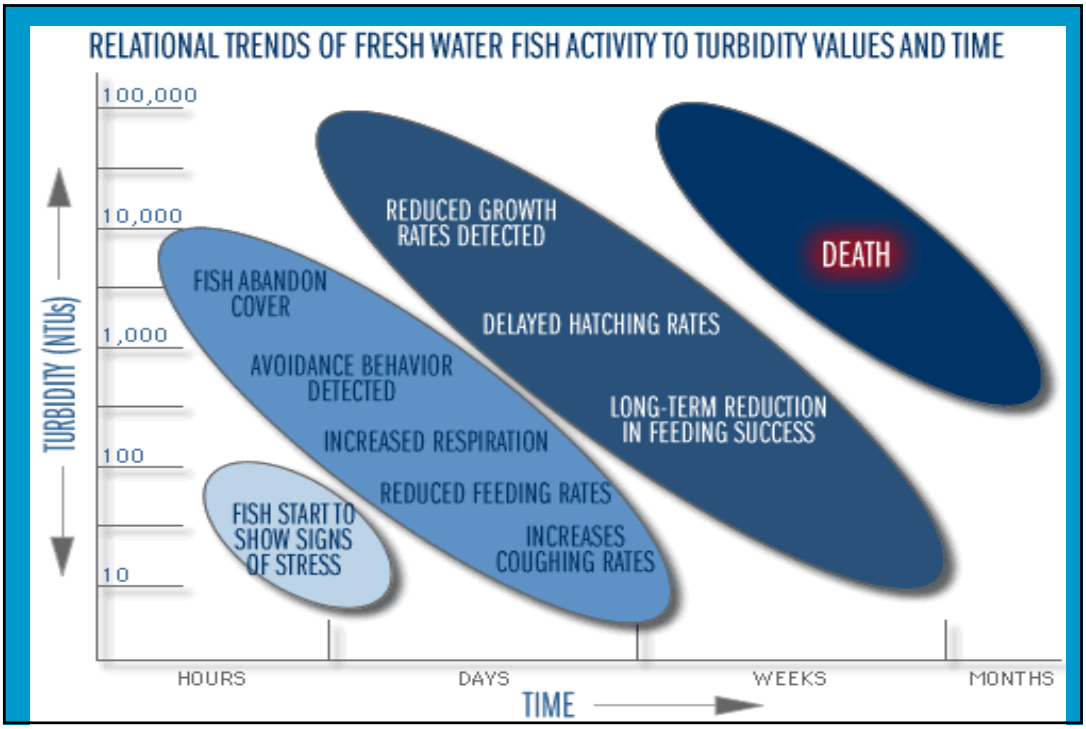

Photo courtesy of USDA NRCS

The Effects of Siltation in Rivers and Streams



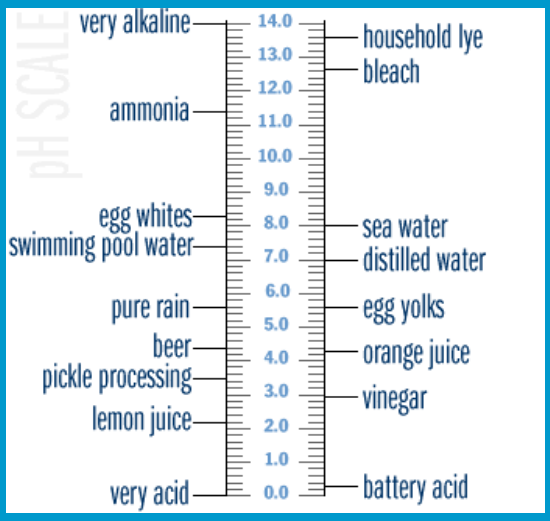


Turbidity meter, imhoff cones, and secchi disk for measuring suspended solids & water clarity



Other measures: pH

- Measure of hydrogen ion concentration
- Typically 6.5 s.u. to 9.0 s.u. needed for most biota
- Determines the solubility and bioavailability of various chemicals
- Useful for detecting acid mine drainage, poor wastewater treatment

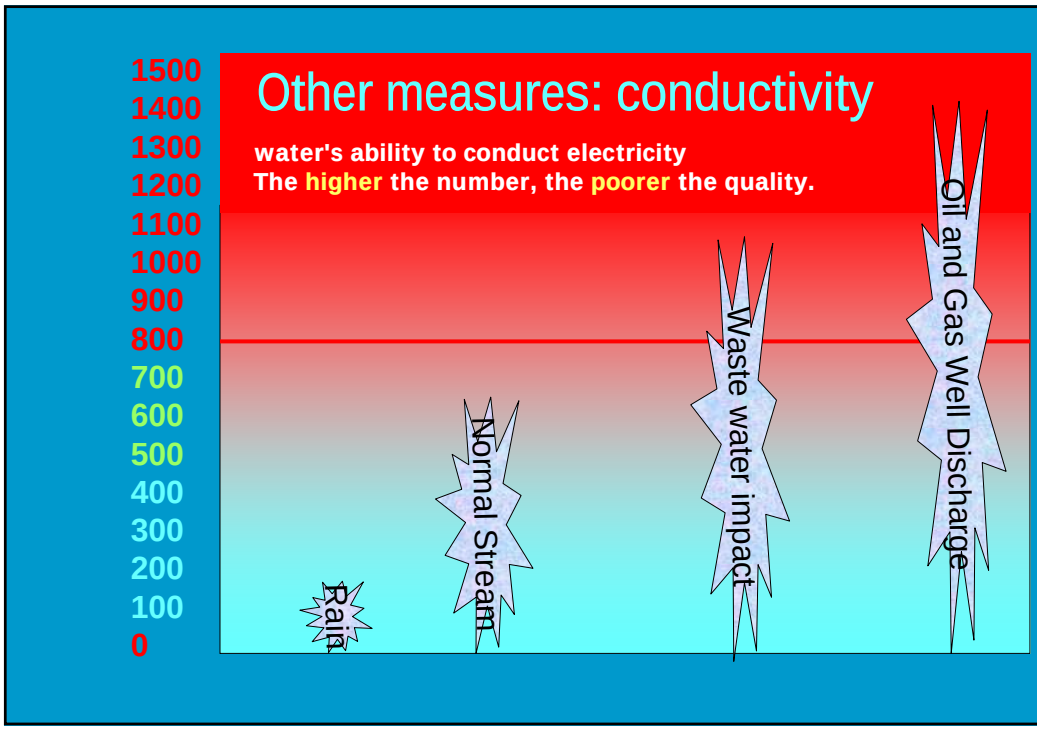



LaMOTTE
WIDE RANGE pH TEST KIT
WR Ind


Insta TEST
Insta TEST
Insta TEST

pH testers

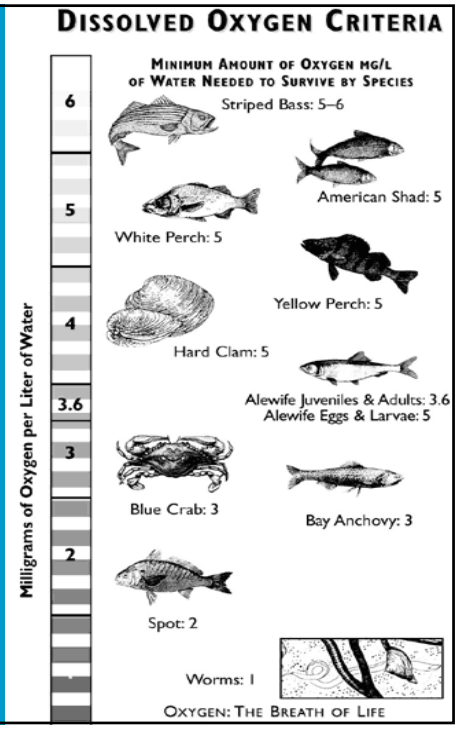

272
ORP
pH
3P
CAL
MS
MR
ULTRAMETER


1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Other measures: conductivity
water's ability to conduct electricity
The higher the number, the poorer the quality.
Rain
Normal Stream
Waste water impact
Oil and Gas Well Discharge

Conductivity meter (and you get a thermometer!)

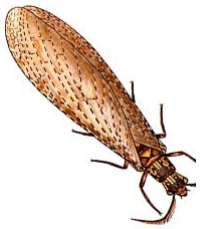
Other measures: dissolved oxygen

Helps to detect sewage, organic loading, oxidizing chemical inputs



Other measures: Macroinvertebrate analysis – inexpensive & comprehensive

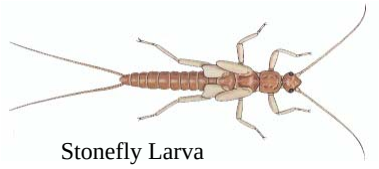
Helgrammite Larva



Dobsonfly Adult

Mayfly Adult

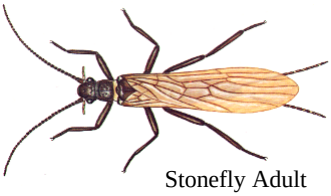
Mayfly Larva



Stonefly Larva

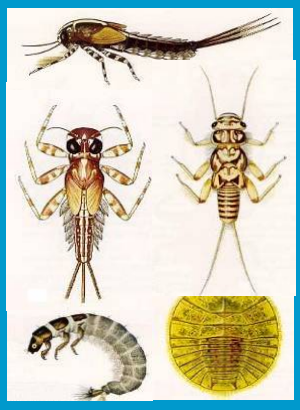
Dragonfly Larva

Dragonfly Adult

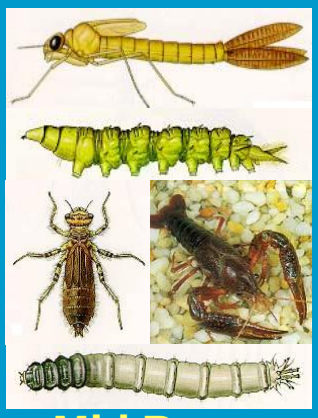


Stonefly Adult

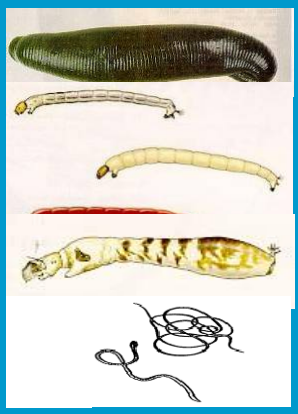
Organisms can be categorized according to their tolerance for pollution or poor habitat conditions



Good



Mid Range



Poor

What about the structure of streams and rivers?

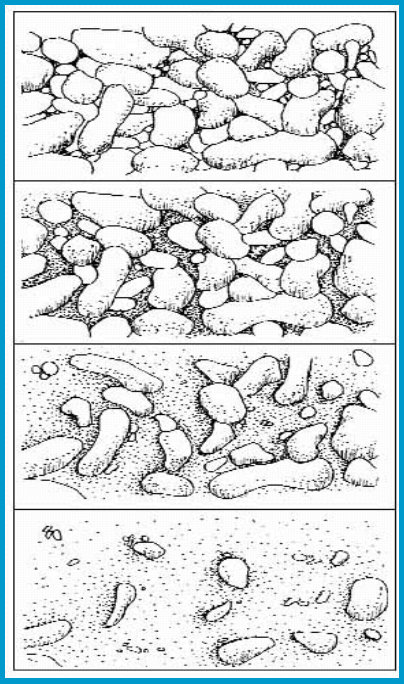
Moving from the biological to the physical: siltation and other structural (physical) aspects of the stream affects habitat

Optimal

Suboptimal

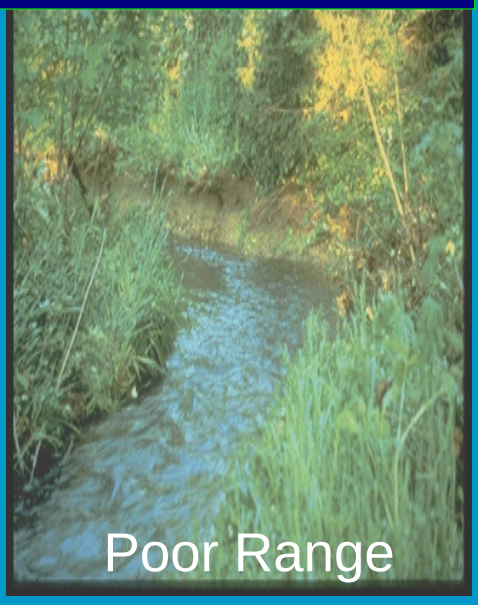
Marginal

Poor



Stream Bottom Structure & Critter Cover

Optimal



Poor Range

Embeddedness

Optimal

Poor Range

Sediment Deposition

Optimal

Poor Range

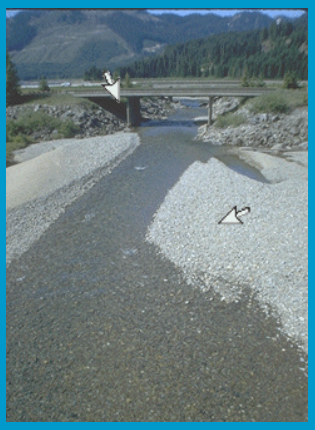
Channel Flow Status

Optimal

Poor Range

Channel Alteration

Optimal



Poor Range

Bank Stability

Optimal

Poor Range

Bank Vegetative Protection

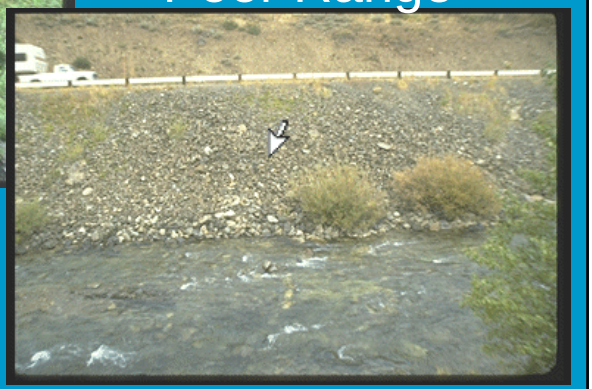
Optimal

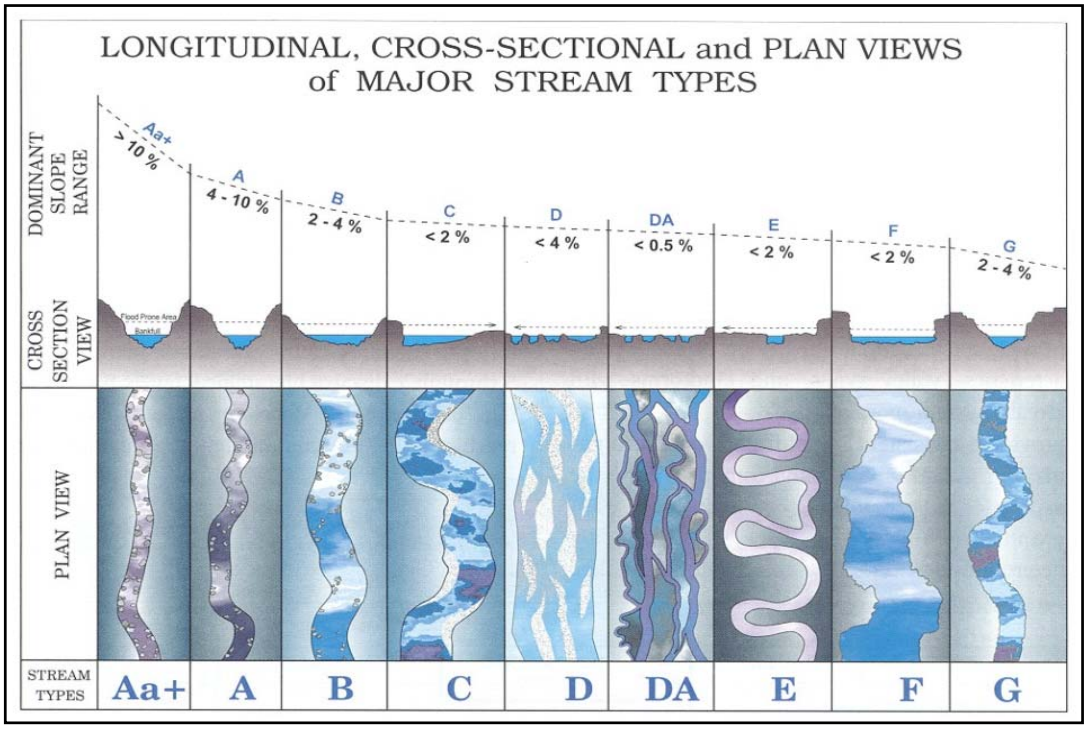
Poor Range

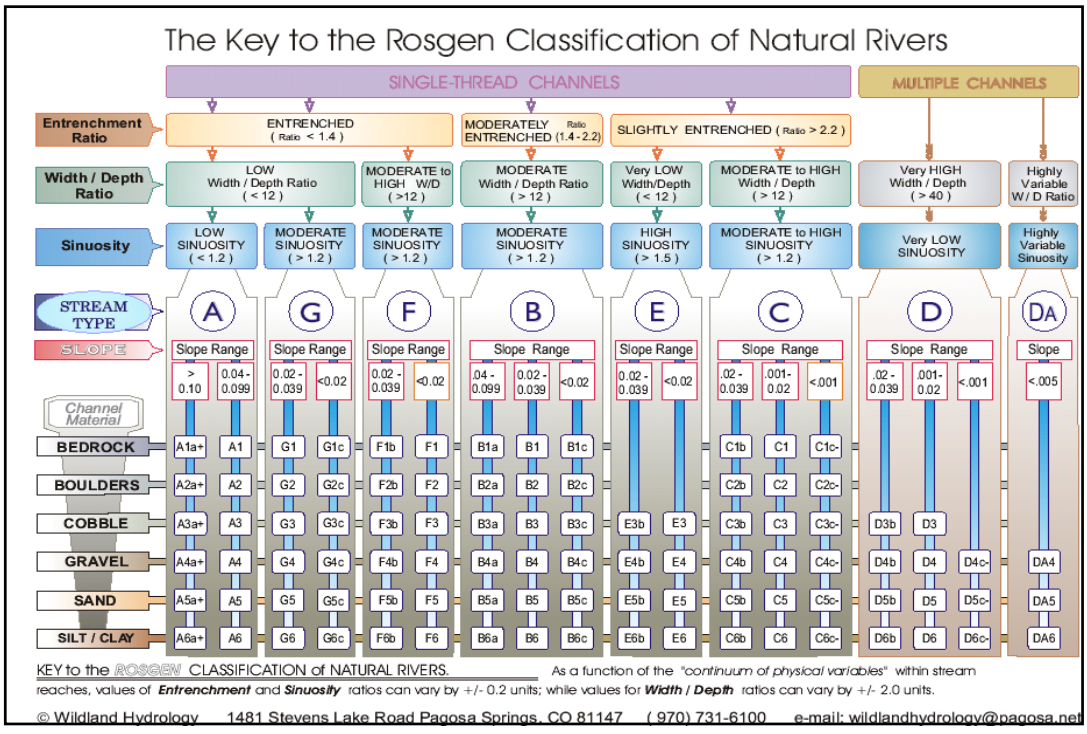
Riparian Vegetative Zone Width

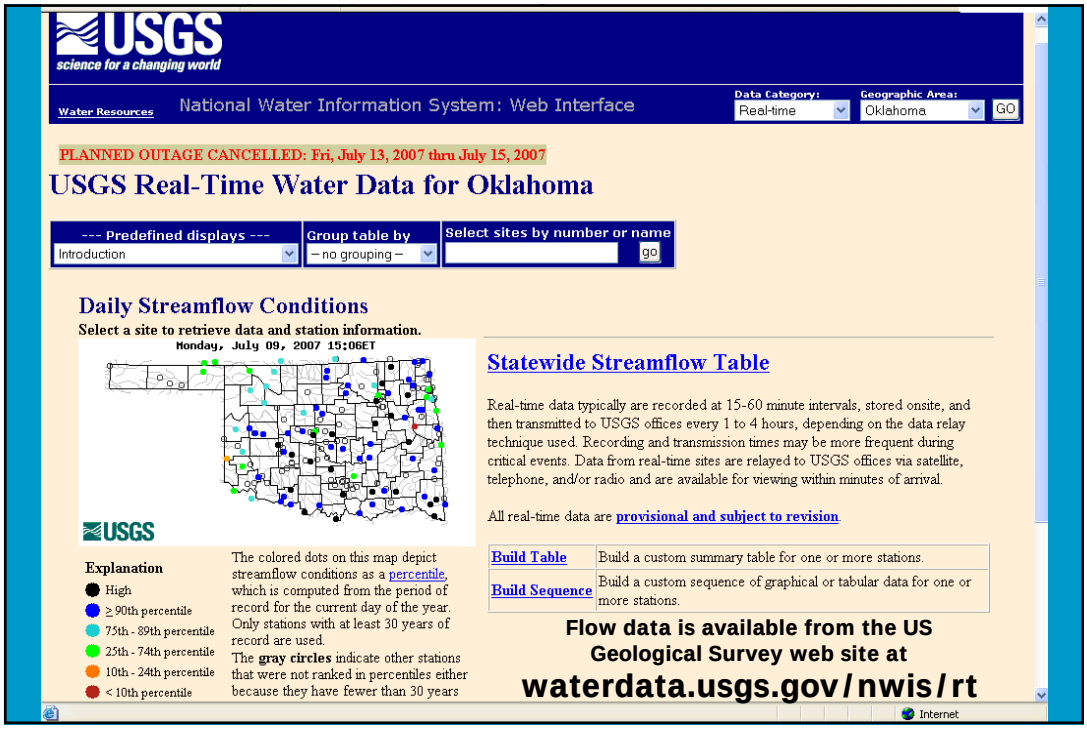
Optimal

Poor Range




LONGITUDINAL, CROSS-SECTIONAL and PLAN VIEWS
of MAJOR STREAM TYPES
DOMINANT SLOPE RANGE
CROSS SECTION VIEW
PLAN VIEW
STREAM TYPES
Aa+
> 10 %
A
4 - 10 %
B
2 - 4 %
C
< 2 %
D
< 4 %
DA
< 0.5 %
E
< 2 %
F
< 2 %
G
2 - 4 %
Aa+
A
B
C
D
DA
E
F
G


The Key to the Rosgen Classification of Natural Rivers
SINGLE-THREAD CHANNELS
MULTIPLE CHANNELS
Entrenchment Ratio
ENTRENCHED (Ratio < 1.4)
MODERATELY ENTRENCHED (1.4 - 2.2)
SLIGHTLY ENTRENCHED (Ratio > 2.2)
Width / Depth Ratio
LOW Width / Depth Ratio (< 12)
MODERATE to HIGH W/D (>12)
MODERATE Width / Depth Ratio (> 12)
Very LOW Width/Depth (< 12)
MODERATE to HIGH Width / Depth (> 12)
Very HIGH Width / Depth (> 40)
Highly Variable W / D Ratio
Sinuosity
LOW SINUOSITY (< 1.2)
MODERATE SINUOSITY (> 1.2)
MODERATE SINUOSITY (> 1.2)
MODERATE SINUOSITY (> 1.2)
HIGH SINUOSITY (> 1.5)
MODERATE to HIGH SINUOSITY (> 1.2)
Very LOW SINUOSITY
Highly Variable Sinuosity
STREAM TYPE
A
G
F
B
E
C
D
DA
SLOPE
Slope Range
> 0.10
0.04 - 0.099
0.02 - 0.039
<0.02
0.02 - 0.039
<0.02
.04 - 0.099
0.02 - 0.039
<0.02
0.02 - 0.039
<0.02
.02 - 0.039
.001 - 0.02
<.001
.02 - 0.039
.001 - 0.02
<.001
Slope
<.005
Channel Material
BEDROCK
BOULDERS
COBBLE
GRAVEL
SAND
SILT / CLAY
A1a+ A1 G1 G1c F1b F1 B1a B1 B1c C1b C1 C1c-
A2a+ A2 G2 G2c F2b F2 B2a B2 B2c C2b C2 C2c-
A3a+ A3 G3 G3c F3b F3 B3a B3 B3c E3b E3 C3b C3 C3c- D3b D3
A4a+ A4 G4 G4c F4b F4 B4a B4 B4c E4b E4 C4b C4 C4c- D4b D4 D4c- DA4
A5a+ A5 G5 G5c F5b F5 B5a B5 B5c E5b E5 C5b C5 C5c- D5b D5 D5c- DA5
A6a+ A6 G6 G6c F6b F6 B6a B6 B6c E6b E6 C6b C6 C6c- D6b D6 D6c- DA6
KEY to the ROSGEN CLASSIFICATION of NATURAL RIVERS.
As a function of the "continuum of physical variables" within stream reaches, values of Entrenchment and Sinuosity ratios can vary by +/- 0.2 units; while values for Width / Depth ratios can vary by +/- 2.0 units.
© Wildland Hydrology 1481 Stevens Lake Road Pagosa Springs, CO 81147 (970) 731-6100 e-mail: wildlandhydrology@pagosa.net


USGS
science for a changing world
Water Resources
National Water Information System: Web Interface
Data Category:
Real-time
Geographic Area:
Oklahoma
GO
PLANNED OUTAGE CANCELLED: Fri, July 13, 2007 thru July 15, 2007
USGS Real-Time Water Data for Oklahoma
--- Predefined displays ---
Introduction
Group table by
– no grouping –
Select sites by number or name
go
Daily Streamflow Conditions
Select a site to retrieve data and station information.
Monday, July 09, 2007 15:06ET
USGS
Explanation
High
≥ 90th percentile
75th - 89th percentile
25th - 74th percentile
10th - 24th percentile
< 10th percentile
The colored dots on this map depict streamflow conditions as a percentile, which is computed from the period of record for the current day of the year. Only stations with at least 30 years of record are used.
The gray circles indicate other stations that were not ranked in percentiles either because they have fewer than 30 years
Statewide Streamflow Table
Real-time data typically are recorded at 15-60 minute intervals, stored onsite, and then transmitted to USGS offices every 1 to 4 hours, depending on the data relay technique used. Recording and transmission times may be more frequent during critical events. Data from real-time sites are relayed to USGS offices via satellite, telephone, and/or radio and are available for viewing within minutes of arrival.
All real-time data are provisional and subject to revision.
Build Table
Build a custom summary table for one or more stations.
Build Sequence
Build a custom sequence of graphical or tabular data for one or more stations.
Flow data is available from the US Geological Survey web site at
waterdata.usgs.gov/nwis/rt
Internet

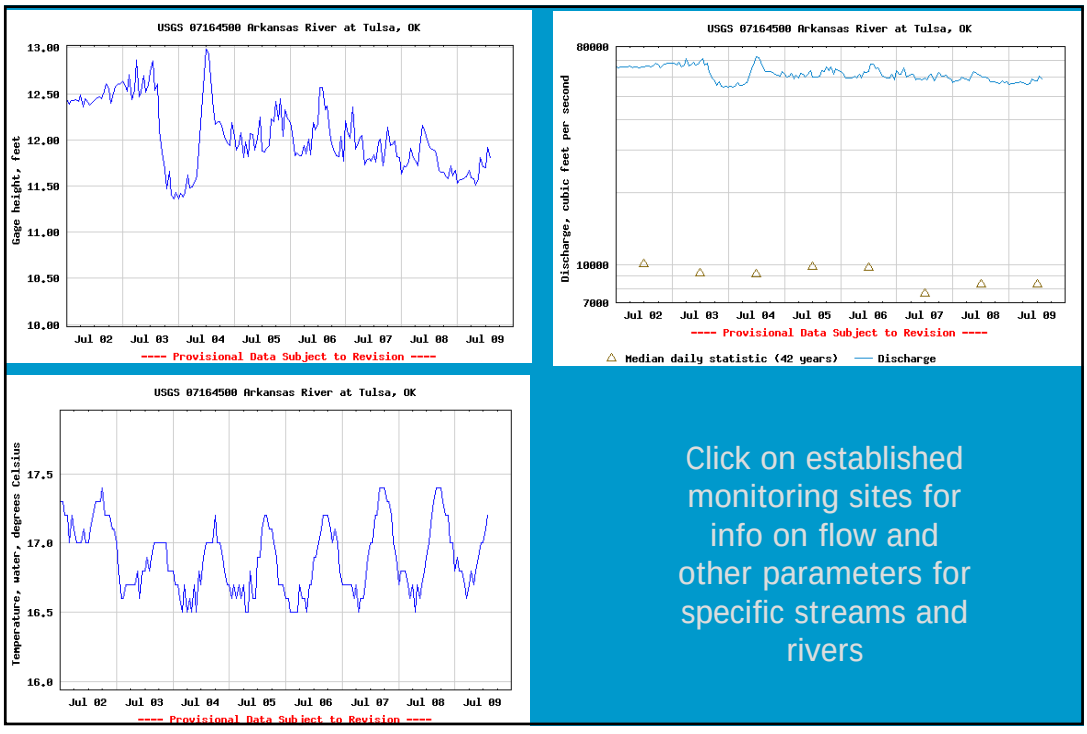

USGS 07164500 Arkansas River at Tulsa, OK
Gage height, feet
13.00
12.50
12.00
11.50
11.00
10.50
10.00
Jul 02
Jul 03
Jul 04
Jul 05
Jul 06
Jul 07
Jul 08
Jul 09
---- Provisional Data Subject to Revision ----
USGS 07164500 Arkansas River at Tulsa, OK
Discharge, cubic feet per second
80000
10000
7000
---- Provisional Data Subject to Revision ----
Median daily statistic (42 years)
Discharge
USGS 07164500 Arkansas River at Tulsa, OK
Temperature, water, degrees Celsius
17.5
17.0
16.5
16.0
---- Provisional Data Subject to Revision ----
Click on established monitoring sites for info on flow and other parameters for specific streams and rivers

Table 2-2. Summary of Common Pollutants and Sources

Pollutant	Potential Sources		Impacts on Waterbody Uses
	Point Sources	Nonpoint Sources	
Pathogens	• WWTPs • CSOs/SSOs • Permitted CAFOs • Discharges from meat processing facilities • Landfills	• Animals (domestic, wildlife, livestock) • Malfunctioning septic systems • Pastures • Boat pumpout facilities • Land application of manure • Land application of wastewater	• Primarily human health risks • Risk of illness from ingestion or from contact with contaminated water through recreation • Increased cost of treatment of drinking water supplies • Shellfish bed closures
Metals	• Urban runoff • WWTPs • CSO/SSOs • Landfills • Industrial facilities • Mine discharges	• Abandoned mine drainage • Hazardous waste sites (unknown or partially treated sources) • Marinas	• Aquatic life impairments (e.g., reduced fish populations due to acute/chronic concentrations or contaminated sediment) • Drinking water supplies (elevated concentrations in source water) • Fish contamination (e.g., mercury)
Nutrients	• WWTPs • CSOs/SSOs • CAFOs • Discharge from food- processing facilities • Landfills	• Cropland (fertilizer application) • Landscaped spaces in developed areas (e.g., lawns, golf courses) • Animals (domestic, wildlife, livestock) • Malfunctioning septic systems • Pastures • Boat pumpout • Land application of manure or wastewater	• Aquatic life impairments (e.g., effects from excess plant growth, low DO) • Direct drinking water supply impacts (e.g., dangers to human health from high levels of nitrates) • Indirect drinking water supply impacts (e.g., effects from excess plant growth clogging drinking water facility filters) • Recreational impacts (indirect impacts from excess plant growth on fisheries, boat/swimming access, appearance, and odors) • Human health impacts
Sediment	• WWTPs • Urban stormwater systems	• Agriculture (cropland and pastureland erosion) • Silviculture and timber harvesting • Rangeland erosion • Excessive streambank erosion • Construction • Roads • Urban runoff • Landslides • Abandoned mine drainage • Stream channel modification	• Fills pools used for refuge and rearing • Fills interstitial spaces between gravel (reduces spawning habitat by trapping emerging fish and reducing oxygen exchange) • When suspended, prevents fish from seeing food and can clog gills; high levels of suspended sediment can cause fish to avoid the stream • Taste/odor problems in drinking water • Impairs swimming/boating because of physical alteration of the channel • Indirect impacts on recreational fishing
Temperature	• WWTPs • Cooling water discharges (power plants and other industrial sources) • Urban stormwater systems	• Lack of riparian shading • Shallow or wide channels (due to hydrologic modification) • Hydroelectric dams • Urban runoff (warmer runoff from impervious surfaces) • Sediment (cloudy water absorbs more heat than clear water) • Abandoned mine drainage	• Causes lethal effects when temperature exceeds tolerance limit • Increases metabolism (results in higher oxygen demand for aquatic organisms) • Increases food requirements • Decreases growth rates and DO • Influences timing of migration • Increases sensitivity to disease • Increases rates of photosynthesis (increases algal growth, depletes oxygen through plant decomposition) • Causes excess plant growth

Note: WWTP = wastewater treatment plant; CSO = combined sewer overflow; SSO = sanitary sewer overflow; CAFO = concentrated animal feeding operation; DO = dissolved oxygen.

Best Management Practices & Management Measures

Common NPS pollutants

- Nutrients
  - From manure, fertilizers, septic systems, and soil runoff
- Pathogens
  - From livestock, pets, and human waste (septic and wastewater treatment systems)
- Sediment
  - From row crop land, construction sites, stream bank erosion, forest roads

Agriculture: Common NPS Pollutants

- Nutrients
  - Nitrogen
  - Phosphorus
- Sediment
- Animal Wastes
- Salts
- Pesticides

Forestry: Common NPS Pollutants

- Sediment
- Temperature
- Flow changes
- Organic debris
- Nutrients
- Flow barriers
- Chemicals (herbicides, insecticides, and fungicides)

Urban areas: Common NPS pollutants

- Sediment
- Petroleum products
- Metals
- Pathogens
- ↑Temperature
- Nutrients
- Habitat impacts
- Litter and debris

General categories of BMPs

- Control pollutants at the source
  - Promote stormwater infiltration
  - Seed & mulch bare areas immediately
  - Clean up dump sites and other polluted runoff areas
- Manage special wastes
  - Livestock manure containment/management
  - Septic system upgrades
  - Mine tailings and drainage
- Prevent stream & river bank erosion
  - Preserve vegetation along banks; manage livestock access
  - Control upland runoff after development
- Redesign “developed” areas
  - Preserve existing site drainage features & vegetation
  - Promote infiltration and detention

BMPs For Livestock

- Rotational grazing
- Waste management systems
- Waste storage structures
- Off-stream watering
- Manure utilization
- Streambank fencing

Cattle management as a BMP

- Know the vegetation, know the type of animals
- Coordinate grazing with precipitation and plant growth
- Use water, fencing, salt, supplements, and herding to manage location of animals
- Check for uniform grazing throughout the grazing unit
- Prevent animals from congregating on streambanks or erodible areas
- Roads can be big sources of sediment – manage their use

Rangeland pasture management

- Pay attention to pasture vegetation growth
- Bare soil in pasture means too many animals
- Move animals before they eat re-growth
- Keep them away from stream banks
- Intensive grazing = more animals, less time
- Herding + strategic placement of supplements = less damage to riparian vegetation

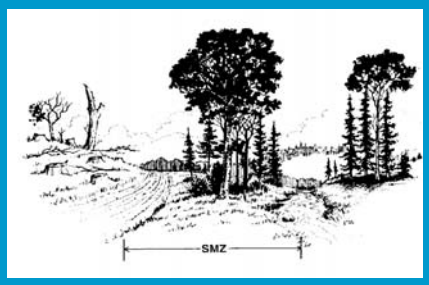
Vegetated buffers along streams & washes

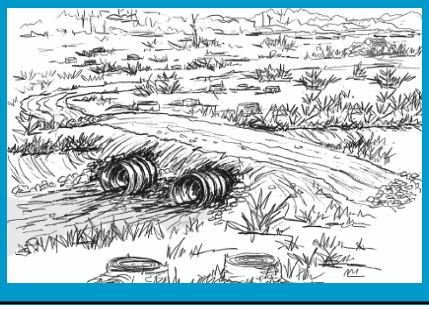

Typical Stock Pond Management
Ideal Stock Pond Management
Remote watering with the nose pump
AQUAMAT


Manure management

Timber harvest BMPs

- Minimize road construction
- Skid logs on the contour
- Protect stream buffers
- Minimize stream crossings
- Keep out of streams & ditches
- Replant slopes quickly





Haul Roads

- Construct on grades of less than 10-15 percent
- Use Broad Based Dips that are designed for continuous use
- Non-erodible running/skid surfaces needed in SMZ and at stream approaches

Skid Trail Stabilization

- Water bars most commonly used on temporary trails
- Install water bars at a 30 to 45 degree angle downslope
- Number needed depends on steepness of slope
- Have an outlet so runoff can disperse onto the leaf litter
- If greater than 5% slope, seed and mulch

BMPs For Channel Modification

- Streambank protection
- Channel stabilization and flow restrictors
- Check dam systems
- Grade control structures
- Non-eroding roadways
- Setback levees and flood walls
- Vegetative cover

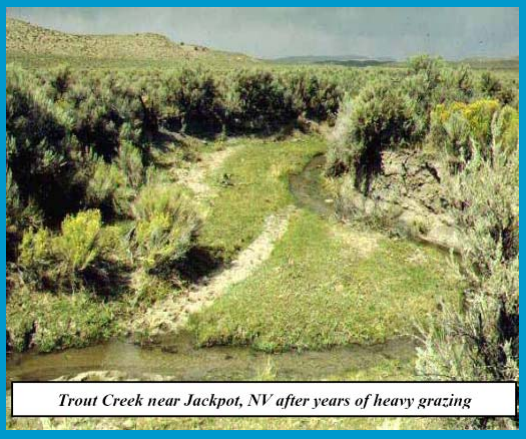
BMPs For Streambank Erosion

- Soil bioengineering
  - Live staking
  - Live fascines
  - Brush layering
  - Brush mattresses
  - Branch packing
  - Joint planting
  - Live cribwalls
- Avoid streams if possible!

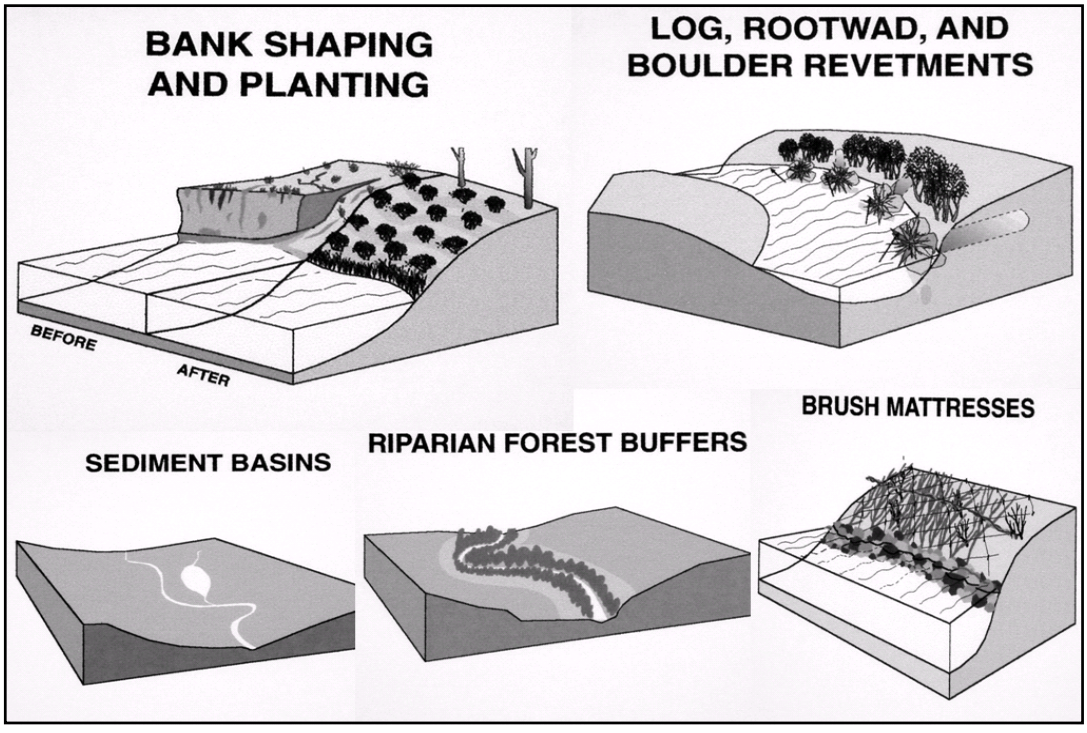
Pueblo of Acoma, NM

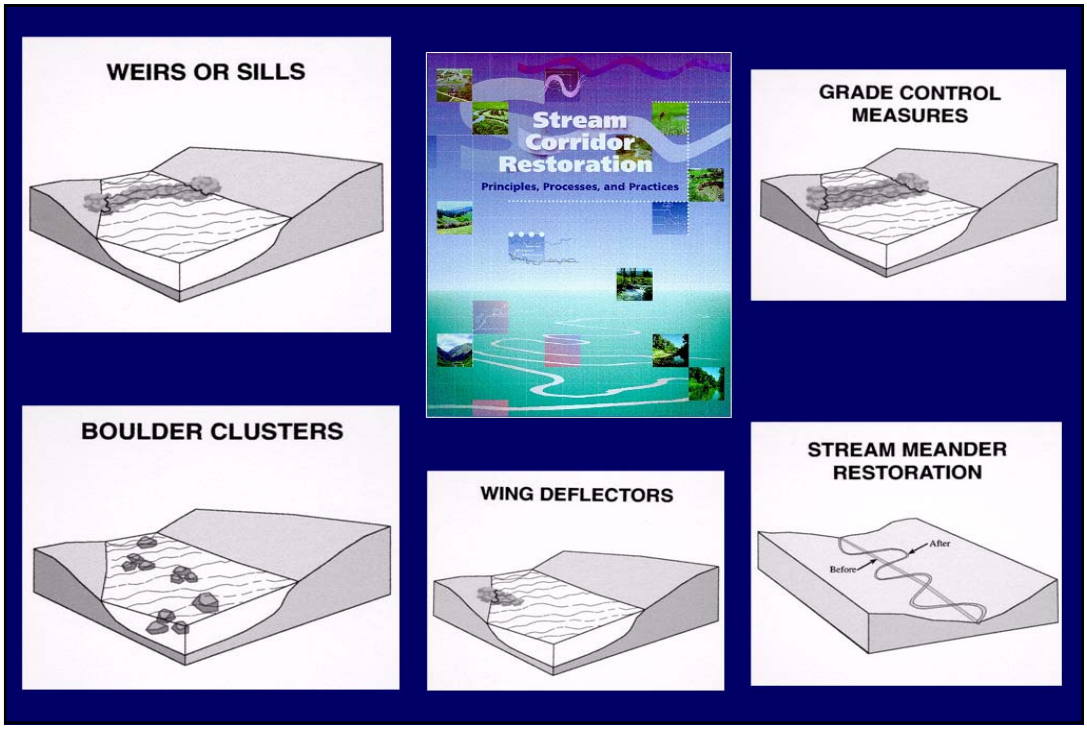
BMPs: Streambank Erosion (cont)

- Protect shorelines and streambanks by installing:
  - Native vegetation
  - Rootwads & logs
  - Bulkheads and seawalls
  - Revetments
  - Gabions
  - Breakwaters



Trout Creek near Jackpot, NV after years of heavy grazing





Live Stakes / Brush Mattress

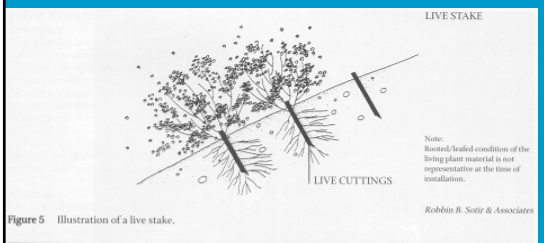


Figure 5 Illustration of a live stake.

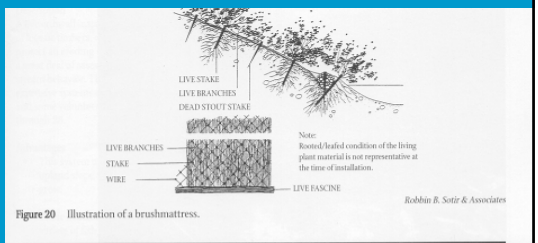
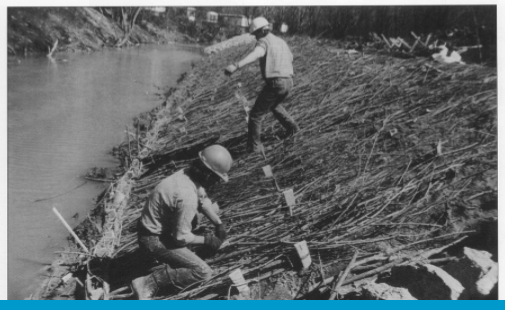
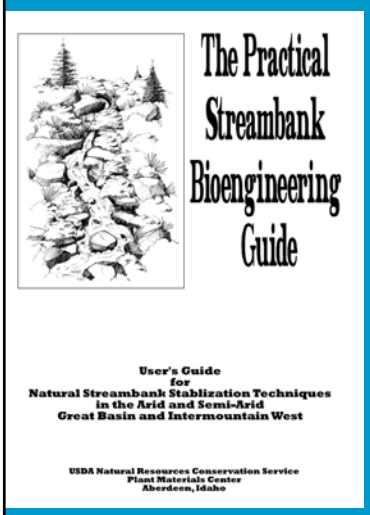
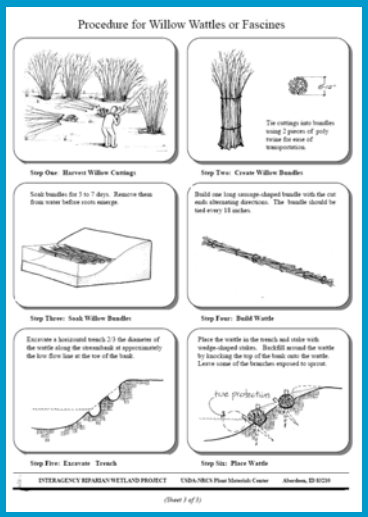
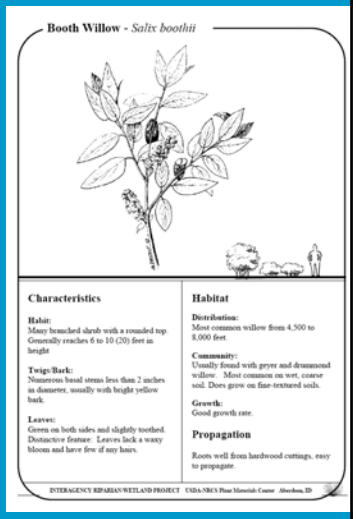


Figure 20 Illustration of a brushmattress.









http://www.ser.org/sernw/pdf/NRCS_idaho_bioengineering_guide.pdf

Stream bank protection with erosion control blankets during installation and after seed emergence

Bank stabilization using open-celled concrete “blankets”

Better wastewater treatment

The Five Ss for NPS Management

- **Soak it in** – promote infiltration
- **Slow it down** – don't let gullies form
- **Spread it around** – no concentrated flows
- **Sift it through** – use silt fences & sediment barriers
- **Settle it out** – detention/stormwater ponds

EPA Guidance on BMPs for nonpoint sources

http://www.epa.gov/owow/nps/pubs.html

- BMP guidance documents on:
  - Agriculture
  - Forestry
  - Urban areas
  - Marinas
  - Hydromodification
  - Wetlands
  - Coastal protection